

Clean Water Act §319(h) Nonpoint Source Grant Program

Implementing the Pecos River Watershed Protection Plan through Continuous Water Quality Monitoring and Dissolved Oxygen Modeling

TSSWCB Project # 09-08

Quality Assurance Project Plan Texas State Soil and Water Conservation Board

Revision 0

prepared by
Texas AgriLife Research
Texas Water Resources Institute
and the
Texas Institute of Applied Environmental Research

Effective Period: June 2010 to October 2012

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Section A1 Approval Sheet

Quality Assurance Project Plan (QAPP) for the *Implementing the Pecos River Watershed Protection Plan through Continuous Water Quality Monitoring and Dissolved Oxygen Modeling* project.

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Signature: _____ Date: _____

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Title: USEPA Texas Nonpoint Source Project Manager (PM)

Signature: _____ Date: _____

Texas State Soil and Water Conservation Board (TSSWCB)

Name: Mitch Conine
Title: TSSWCB PM

Signature: _____ Date: _____

Name: Donna Long
Title: TSSWCB Quality Assurance Officer (QAO)

Signature: _____ Date: _____

Texas AgriLife Research - Texas Water Resources Institute (TWRI)

Name: Bill Harris
Title: Acting Director, TWRI Project Lead

Signature: _____ Date: _____

Name: Lucas Gregory
Title: TWRI QAO

Signature: _____ Date: _____

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Name: Larry Hauck
Title: TIAER Lead Scientist

Signature:_____Date:_____

Name: Nancy Easterling
Title: TIAER QAO

Signature:_____Date:_____

Section A2: Table of Contents

Section: Title

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List of Acronyms and Abbreviations

BMP	best management practice
CAR	corrective action report
CWA	Clean Water Act
CWQM	Continuous Water Quality Monitoring
DM	data manager
DO	dissolved oxygen
DQO	data quality objectives
GIS	geographic information system
IBWC	International Boundary and Water Commission
PM	project manager
QA	quality assurance
QAPP	quality assurance project plan
QAO	Quality Assurance Officer
QC	quality control
QPR	quarterly progress report
SWQMIS	Surface Water Quality Management Information System
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TNRIS	Texas Natural Resources Information System
TIAER	Texas Institute of Applied Environmental Research
TSSWCB	Texas State Soil and Water Conservation Board
TWRI	Texas Water Resources Institute
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WPP	Watershed Protection Plan

Section A3: Distribution List

Organizations, and individuals within, which will receive copies of the approved QAPP and any subsequent revisions include:

United States Environmental Protection Agency, Region VI

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Dallas, TX 75202-2733

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Title: USEPA Chief State/Tribal Programs Section

Name: Henry Brewer
Title: USEPA Texas Nonpoint Source PM

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Name: Lucas Gregory
Title: TWRI QAO

Tarleton State University - Texas Institute of Applied Environmental Research

Box T-0410
Stephenville, TX 76402

Name: Larry Hauck
Title: Lead Scientist

Name: Nancy Easterling
Title: TIAER QAO

Section A4: Project/Task Organization

The following is a list of individuals and organizations participating in the project with their specific roles and responsibilities:

USEPA – Provides project oversight and funding at the federal level.

Henry Brewer, USEPA Texas Nonpoint Source PM

Responsible for overall performance and direction of the project at the federal level. Ensures that the project assists in achieving the goals of the clean water act (CWA). Reviews and approves the quality assurance project plan (QAPP), project progress, and deliverables.

TSSWCB –Texas State Soil and Water Conservation Board, Temple, Texas. Provides project overview at the State level.

Mitch Conine, TSSWCB PM

Responsible for ensuring that the project delivers data of known quality, quantity, and type on schedule to achieve project objectives. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified. Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TSSWCB participants.

Donna Long; TSSWCB QAO

Reviews and approves QAPP and any amendments or revisions. Responsible for verifying that the QAPP is followed by project participants. Monitors implementation of corrective actions. Coordinates or conducts audits of field and laboratory systems and procedures. Determines that the project meets the requirements for planning, quality assessment (QA), quality control (QC), and reporting under the TSSWCB Total Maximum Daily Load Program.

TWRI – Texas AgriLife Research, Texas Water Resources Institute, College Station, Texas. Responsible for development of data quality objectives (DQOs) and a QAPP.

Bill Harris, Project Lead

The TWRI Project Lead is responsible for ensuring that tasks and other requirements in the contract are executed on time and with the QA/QC requirements in the system as defined by the contract and in the project QAPP; assessing the quality of subcontractor/participant work; and submitting accurate and timely deliverables to the TSSWCB PM.

Lucas Gregory, Quality Assurance Officer & PM

Responsible for determining that the QAPP meets the requirements for planning, QA and QC. Conducts audits of field and laboratory systems and procedures. Responsible for maintaining the official, approved QAPP, as well as conducting

quality assurance audits in conjunction with TSSWCB personnel. Responsible for ensuring the timely completion of project deliverables, fiscal oversight and project reporting.

TIAER– Texas Institute of Applied Environmental Research, Tarleton State University, Stephenville, Texas. Responsible for modeling activities associated with the QUAL2K or WASP model used to evaluate dissolved oxygen (DO) concentrations in the Pecos River.

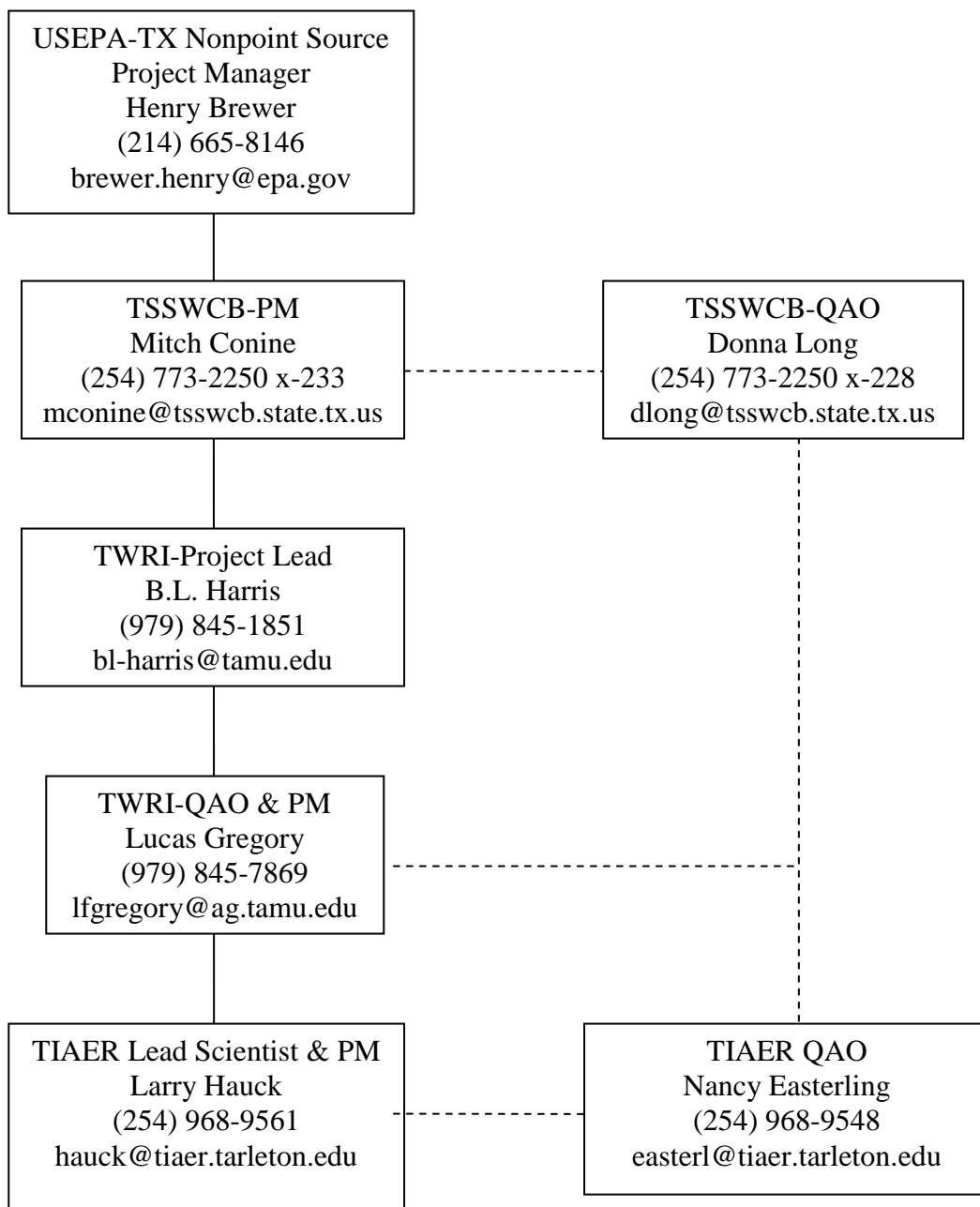
Larry Hauck, Lead Scientist

Responsible for overseeing the utilization of the designated model to evaluate DO levels in the Pecos River in Texas. Responsible for assuring that all QA/QC measures are followed in the application of this model. Responsible for the development of a final project report summarizing model findings.

Nancy Easterling, QAO

Responsible for ensuring that modeling work conducted at TIAER is done in accordance with all QA/QC requirements set forth in the project QAPP. Coordinates the research and review of technical QA material and data related to the model system design and analytical techniques. Implements or ensures implementation of corrective actions needed to resolve nonconformances noted during assessments. Responsible for notifying TWRI QAO of any QA/QC deficiencies and initiating proper corrective measures.

Figure A.4.1. Project Organization Chart



Section A5: Problem Definition/Background

The Pecos River is a greatly depleted western river flowing 418 winding miles through hot, dry, semi-arid landscapes in Texas. It is the largest river sub-basin flowing into the Rio Grande River from the United States. The Pecos River itself is also the lifeblood of many communities within its reaches, mainly as an irrigation source, recreational uses, and as recharge for underlying aquifers. As such, its importance historically, biologically and hydrologically to the future of the Rio Grande Basin is critical. The flows of the once great Pecos River have dwindled to a mere trickle due to many causes – some natural and some man-induced. Its upper reaches in Texas now resemble a small creek rather than a river. If the integrity of the entire Rio Grande basin below the Pecos is to be improved and maintained, then it is crucial that both the water quality and quantity of Pecos flows be improved and stabilized within a natural flow regime.

Due to the lowered water quality and stream flows in the upper portion of the river, the aquatic community of the Pecos River has been drastically altered according to reports from biologists and to local users of the river. No longer does the river support as many diverse communities of aquatic plants, invertebrates, microorganisms, fish and amphibians as is described in *A Watershed Protection Plan for the Pecos River in Texas (Pecos River WPP)*. The greatly reduced aquatic diversity has been negatively affected by changes in river hydrology, riparian community destruction, oil and gas activities, irrigation demands, long and short-term droughts, damming of the river and the desertification of the upland watershed due to several factors. These factors, both natural and man-made, have allowed introduced plant species, such as saltcedar, to dominate the riparian corridor and other nuisance brush species to become firmly established on upland areas and have likely contributed to water quality declines, such as the DO impairment in the upper reaches of the river (assessment units 2311_05 and 2311_06).

According to data from the U.S. Section of the International Boundary and Water Commission (IBWC), the Pecos River contributes 274 million m³ of streamflow annually to the Rio Grande, which accounts for approximately 11% of the total annual inflow to Amistad International Reservoir. However, it also contributes to the total dissolved solids (salt) loading into the reservoir at an annual rate of 0.54 million tons or 29.5% of the total annual salt load. The concentration of total dissolved solids (TDS) of the Amistad International Reservoir exceeded 1,000 ppm for a month in 1988, and has fluctuated since. It is important to control salt loading from the Pecos to Rio Grande if TDS of the reservoir are to be kept in compliance with the Texas Water Quality Standards. Several key areas where dissolved solids enter the river have been identified and quantified.

This project addresses two critical needs as identified in the Pecos River WPP. Water quality monitoring in the watershed is rather limited and needs improvement. The WPP specifically calls for the establishment of 4 new Continuous Water Quality Monitoring (CWQM) stations at locations across the watershed; a new CWQM station at Girvin, TX is prioritized as an immediate, short-term need in the WPP. This project will implement one new CWQM station in cooperation with the Texas Commission on Environmental Quality (TCEQ) which will enhance data collection in the watershed and provide water quality data in conjunction with United State Geological Survey (USGS) monitored flow data (USGS gage 08446500; Pecos River near Girvin, TX). Data from this particular location will be critical to assess the impacts of implementing the Pecos River WPP, particularly invasive species control (saltcedar) in this portion of the watershed through TSSWCB project 08-08, *Implementing Components of the Watershed Protection Plan for the Pecos River in Texas*. Establishing a CWQM station at this site will accomplish two main objectives; 1) it will enable the river's users to have a better understanding of water quality trends in the river, and 2) it will allow

pollutant loads to be calculated at Girvin and provide a concrete indication of water quality changes as a result of implementing best management practices (BMPs) from the Pecos River WPP.

The *WPP for the Pecos River in Texas*, as well as the letter received from U.S. Environmental Protection Agency USEPA Region 6 following their consistency review of the WPP, indicate the need for further assessment and the development of recommended management measures to address the DO impairment in the upper portions of the river; specifically assessment units 2311_05 and 2311_06. This project will accomplish this need by employing computer-based DO modeling to assess historical water quality data on the Pecos River and identify the causes and sources of the DO impairments in the river, develop an estimate of load reductions needed to achieve water quality restoration, and evaluate the impact of BMPs recommended in the Pecos River WPP.

Conducting computer-based DO modeling is the second objective of this project and will be conducted by TIAER to identify the sources of pollution that influence DO levels in the Pecos River and have led to the current DO impairment in its upper reaches. Currently available data (streamflow, water quality, water rights withdrawals, and wastewater treatment facility discharges, etc.) will be utilized in this evaluation. The primary goals of the modeling exercise are to 1) identify

the sources of pollution causing the DO impairment in Segment 2311 and examine DO dynamics in Segment 2310, 2) develop an estimate of load reductions, for each pollutant, needed to achieve water quality restoration, 3) evaluate the ability of BMPs to influence DO levels and potentially reduce pollutant loadings and 4) recommend a suite of BMPs, based on those in the Pecos River WPP, to be implemented throughout the watershed that will effectively lead to the restoration of water quality (DO). Results from this modeling evaluation will be combined into a Technical Report which will be distributed to landowners and entities involved in the development of the Pecos River WPP; based on their recommendations, conclusions from the DO modeling and evaluations of BMPs will be incorporated into future revisions of the WPP and used to guide future BMP implementation. TWRI, with assistance from TIAER, will develop a QAPP for DO modeling activities consistent with the most recent versions of *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* and the *TSSWCB Environmental Data Quality Management Plan*. Through TSSWCB project 08-08 TWRI will coordinate and facilitate public meetings needed to gain local input into the modeling process and to deliver information on the DO modeling process, findings, management recommendation and what benefits can be expected as a result of this implementation.

TWRI will provide financial administration and oversight to the project. All quarterly progress reports and a final report will be provided to the TSSWCB in a consistent and timely fashion by TWRI personnel. The project will be implemented for three years giving TCEQ and TSSWCB consistent continuous water quality monitoring of the Pecos River at Girvin to determine true and necessary parameters to accurately determine success of the Pecos River WPP. During the project, TWRI will make efforts to identify and secure long-term sources of funding to continue the operation and maintenance of both the CWQM station and USGS gage beyond the life of this project.

The results of the modeling effort will be included in a technical report submitted to TSSWCB, TWRI and Texas AgriLife Extension Service for inclusion in the Pecos River WPP (TSSWCB Project 04-11).

Table A6-1. Project Plan Milestones

Task	Project Milestones	Agency	Start	End
1.1	TWRI in cooperation with TCEQ and TIAER will develop and submit quarterly progress reports on the 15 th of Jan., Apr., Jul., and Oct.	TWRI	M 1	M 36
1.2	TWRI will submit appropriate Reimbursement Forms to TSSWCB.	TWRI	M 1	M 36
1.3	TWRI host meetings, calls or TTVNs as appropriate to maintain lines of communication and keep project on task.	TWRI	M 1	M 36
2.1	TCEQ will bring the collection of data at the new CWQM site (Task 3) under their existing USEPA-approved CWQM QAPP	TCEQ	M 1	M 3
2.2	TWRI, with assistance from TIAER (Subtask 4.1) will develop a QAPP for activities in Task 4	TWRI TIAER	M 1	M 3
2.3	TWRI will submit revisions and necessary amendments to the QAPP as needed.	TWRI	M 3	M 36
3.1	TWRI will purchase needed supplies to construct and maintain a deployable CWQM station. TWRI will transfer these supplies to TCEQ.	TWRI	M 1	M 3
3.2	TCEQ will design, construct, test and deploy a continuous water quality monitoring site at the selected location near Girvin, TX upstream of US 67.	TCEQ	M 1	M 4
3.3	TCEQ will operate and maintain the CWQM station and will validate recorded data and ensure that the data is made available through TCEQ webpages, including http://www.texaswaterdata.org .	TCEQ	M 4	M 36
3.4	TCEQ will coordinate with USGS to continue operation and maintenance of discharge monitoring equipment at the USGS gage near Girvin (08446500).	TCEQ	M 4	M 36
3.5	TWRI will work to identify and secure long-term sources of funding to continue the operation and maintenance of both the CWQM site and USGS gage near Girvin.	TWRI	M 1	M 36
4.1	TIAER will evaluate DO models, such as QUAL2K, capable of simulating low-flow steady-state conditions and diel DO fluctuations from aquatic vegetation photosynthesis and respiration. TIAER, TWRI and TSSWCB will select the model to be used. Once the most suitable model is selected, TIAER will assist TWRI in developing a modeling QAPP (Task 2).	TIAER TWRI TSSWCB	M 1	M 6
4.2	TIAER will obtain and evaluate relevant historical data on the Pecos River. TIAER will access databases for pertinent data needed in the next subtask for model development and validation.	TIAER	M 1	M 6
4.3	TIAER will develop and validate against historical data, a QUAL2K model (or similar model) of the Pecos River Segments 2310 and 2311, with specific emphasis on currently impaired assessment units 2311_05 and 2311_06.	TIAER	M 6	M 12
4.4	TIAER will apply the validated model for a series of low-flow base conditions in the Pecos River that represents seasonal conditions in the river. TIAER will then impose on the various base conditions selected BMPs for which the model will predict changes in DO concentrations.	TIAER	M 13	M 24
4.5	Results from this modeling evaluation will be combined into a Technical Report which will be distributed to landowners and entities involved in the development of the Pecos River WPP; based on their recommendations, conclusions from the DO modeling and evaluations of BMPs will incorporated into future revisions of the WPP and used to guide future BMP implementation.	TIAER TWRI	M 25	M 36

Section A7: Quality Objectives and Criteria for Model Inputs / Outputs

Data Quality Objectives (DQOs) are qualitative and quantitative statements that clarify the intended uses of data and define the types of data needed to support decisions. The analytical tools included in this QAPP include mechanistic or processes oriented models for the evaluation of DO impairment in the Pecos River.

Objectives for this project and covered in this QAPP are:

1. Obtain, organize and assess pertinent data to use in model simulations that will assess the stressors and causes of DO impairment in the Pecos River,
2. Use initial data assessment to select the most appropriate computer based model to evaluate DO impairments, their stressors and causes in the Pecos River,
3. Validate the selected DO model using statistical comparison between real and simulated DO levels in historical water quality data,
4. Perform limited sensitivity analysis for key input parameters to determine their individual affect on model outputs, and
5. Apply the validated model to evaluate low-flow base conditions and base conditions with selected BMPs to inform the process of targeting sources and estimating needed load reductions from sources.

Objective 1: Obtain, Organize and Assess Data

The primary focus of this objective is to collect needed input data that are sufficient to run the selected DO water quality model. Specific data sources used are described in detail in section B9 – Non-Direct Measurements and are listed in Table B9.1. Only data that are accepted by state and national agencies (TCEQ and USGS, etc.) will be used; data will be the from the most recently available version or database; data will be specific to the Pecos River watershed when possible; if data (e.g., weather data) from outside the watershed are used; they will be obtained from the nearest representative source; lastly, if near proximity data are not available, literature values and expert judgment will be utilized and confirmed through model validation.

Objective 2: Use Data Assessment to Select the most Appropriate Computer Based Model

Selection of the most appropriate model to evaluate DO levels and fluctuations in the Pecos River is the main focus of this objective. To achieve this objective, data obtained in the first objective (specifically, water quality and hydrologic data) will be evaluated to determine the conditions under which DO impairments occur, which will in turn inform the capabilities needed in the selected model. Based on present understanding of conditions of DO impairment, they occur under low-flow steady-state conditions and more often the non-support of existing DO criteria is for the 24-hour minimum DO criterion rather than the 24-hour average DO criterion. Based on present understanding of the impairment, it is anticipated that the QUAL2K model will be the preferred model due to the diel fluctuations of DO levels in the river. However, WASP will remain an option as the QUAL2K does not include salinity in its internal computations of DO saturation concentrations. The WASP model has the capabilities of QUAL2K, but it is also a much more general model and therefore not as easily

applied to the Pecos River system. (Note: Preliminary test runs of QUAL2K indicate that the model's elevation input for each reach can be artificially manipulated to give the same response as salinity on DO saturation concentrations, and these same preliminary runs indicated this manipulation did not compromise the value of any other parameters in the model output. Systematic testing under this QAPP will be required to confirm these preliminary results, which would allow QUAL2K to be applied to the Pecos River.)

Objective 3: Validate the Selected DO Model using Statistical Comparisons between Real Data and Model Outputs

This objective aims to setup the selected model through a calibration and verification process so that the most realistic model outputs are produced. This process contains two primary steps: calibration and verification. Jointly these two steps are referred to herein as model validation. During calibration model input parameters are systematically adjusted within the range of meaningful values based on observations made in the watershed, literature, and expert judgment for the purpose of achieving an optimal comparison of model output to the observational data in the calibration data sets. Only a portion of the entirety of all validation data sets is used during the calibration step with the remainder used in the verification step. Within the verification step, the model is supplied with the same calibration input data, except for the obvious need to change time dependent input, such as weather, and the output is compared against the verification data using the same graphical and statistical measures used in the calibration process. This validation process is further discussed in Section B7—Model Calibration and Verification [Validation].

Table A7.1 lists proposed calibration and verification targets for the Pecos River DO modeling effort. Because of inherent error in input and observational data, the approximate nature of model formulations in representing the prototype (or real-world) situation, absolute criteria for model acceptance or rejection are not appropriate for this effort. Consequently, the tolerances proposed in Table A7.1 will be used as general targets and goals for the model validation process.

Objective 4: Perform Sensitivity Analysis

A sensitivity test will be performed on key input parameters for the selected DO model(s) to determine response of the predictions of the model(s). This analysis will provide an indication of the importance of knowledge uncertainty on sensitivity kinetic rates and other input parameters on predicted DO concentrations. The sensitivity analysis will be performed by varying pertinent input parameters plus and minus a fixed percentage (e.g., $\pm 50\%$) and evaluating the impact of this change on model predictions of DO concentrations. The model validation process (Objective 3) will be used to guide determination of the appropriate input parameters to be included in the sensitivity analysis. Parameters often included in this type of analysis include: reaeration coefficients, sediment oxygen demand, decay rates of biochemical oxygen demand, and nitrification rates. Since diel DO fluctuations are being simulated, rates governing benthic and suspended algae net growth are also important. Sensitivity analysis results will be presented in graphical mode in the technical report document developed for this task and submitted to TSSWCB.

Table A7-1. Proposed Validation Targets for the Pecos River Steady State Dissolved Oxygen Modeling Effort

Statistical Measure	Property	Target Value
Relative mean error	Streamflow	+/- 30%
Mean error	DO (24-hr average)	+/- 1 mg/L
Mean error	DO (24-hr minimum)	+/- 2 mg/L
Relative mean error	All other water quality constituents	+/- 45%
Parametric paired t-test	Streamflow and water quality constituents (normally distributed data)	insignificant difference at level $\alpha = 0.95$ ($p > 0.05$)
Non-parametric sign test	Streamflow and water quality constituents (non-normally distributed data)	insignificant difference at level $\alpha = 0.95$ ($p > 0.05$)

Objective 5: Perform Applications Using Validated Model

The model validated and tested under Objectives 3 and 4 will be applied to predict DO levels in the Pecos River under a series of low-flow base conditions in the Pecos River and with selected BMPs to predict changes in DO concentrations. The low-flow base conditions will represent pre-BMP conditions on the Pecos River under various seasonal conditions in the river. The BMPs evaluated will include, but not be limited to, options that decrease salinity content, decrease nutrient loadings, increase flow, increase aeration, increase shading and decrease water temperature. Specific BMPs recommended by landowners and entities included in the Pecos River WPP will be included in the model applications.

Section A8: Special Training Requirements/Certification

All personnel involved in model calibration, validation, and development will have the appropriate education and training required to adequately perform their duties. No special certifications are required.

Section A9: Documentation and Records

All modeling records, including modeler's notebooks and electronic files, will be archived by TIAER for at least five years after completion of the project. These records will document model testing, calibration, and evaluation and will include documentation of written rationale for selection of models, record of code verification (hand-calculation checks, comparison to other models), sources of historical data, source of new theory, calibration and sensitivity analyses results, and documentation of adjustments to parameter values due to calibration. Electronic data on the project computers and the network server are backed up daily to a tape drive. In the event of a catastrophic systems failure, the tapes can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost, but can be reproduced from raw data in most cases.

Table A9-1. Document and Records

Document/Record	Location	Retention	Form
QAPPs, amendments, and appendices	TIAER/TWRI	5 years	Paper/Electronic
QAPP distribution documentation	TIAER/TWRI	5 years	Paper/Electronic
Model User's Manual or Guide (including application-specific versions)	TIAER	5 years	Paper
Assessment reports for acquired data	TIAER	5 years	Paper/Electronic
Raw data files	TIAER	5 years	Paper/Electronic
Model input files	TIAER	5 years	Electronic
Model output files	TIAER	5 years	Electronic
Code Verification Reports	TIAER	5 years	Paper
Calibration Report	TIAER	5 years	Paper
Model Assessment Reports	TIAER	5 years	Paper
Progress report/CAR/final report/data	TIAER/TWRI	3 years	Paper/Electronic
Model code and executable	TIAER	5 years	Electronic
Validation log book	TIAER	5 years	Paper

Quarterly progress reports disseminated to the individuals listed in section A3 will note activities conducted in connection with the water quality modeling project, items or areas identified as potential problems, and any variations or supplements to the QAPP. A final technical report on modeling analysis will be developed and will summarize outcomes. Outcomes will be submitted to the established stakeholder group, incorporated into the Pecos WPP and utilized in future management implementation.

Corrective Action Reports (CARs) will be utilized when necessary (Appendix A). CARs will be maintained in an accessible location for reference at TWRI and will be disseminated to the individuals listed in section A3. CARs documenting any changes or variations from the QAPP or any excursions that may impact the quality of the data or output will be made known to pertinent project personnel within 30 days of confirmation of the problem and documented in updates or amendments to the QAPP, as necessary.

Section B1: Sampling Process Design (Experimental Design)

Not relevant. All water quality/quantity data utilized in this project will be obtained from TCEQ's Surface Water Quality Monitoring Information System (SWQMIS) database and USGS's Texas Water Data, which are accepted, QA/QC assured data.

Section B2: Sampling Method Requirements

Not relevant. No new sampling data will be collected through this project.

Section B3: Sample Handling and Custody Requirements

Not relevant. No new sampling will occur through this project.

Section B4: Analytical Methods

Not relevant. No analytical sample analysis will occur through this project.

Section B5: Quality Control Requirements

Not relevant. No new sampling data will be collected through this project.

Section B6: Equipment Testing, Inspection, & Maintenance Requirements

Not relevant. No sampling or sample analysis will be conducted through this project.

Section B7: Model Calibration and Verification

The QUAL2K (preferred) or the WASP model will be selected to evaluate the existing DO impairment in the Pecos River and will need to be calibrated and verified prior to its application. QUAL2K is the preferred model because it was specifically designed for application to stream systems for predicting DO under low steady-flow conditions. WASP contains the same capabilities as QUAL2K regarding DO, but is a more generally applicable model to many types of surface water systems (e.g., streams, lakes, and estuaries) and is designed to deal with unsteady, dynamic flow conditions. Consequently, WASP has greater capabilities than needed for the immediate application and these greater capabilities come with additional burden regarding computer resources and data input. The weakness of QUAL2K to the application on the Pecos River is that its computation of saturating DO concentration does not include the effect of TDS whereas the WASP model does include that effect. However, adjusting the elevation of the modeled waterbody to a higher elevation through model input mimics DO saturation levels under saline conditions and allows the model to realistically model DO levels that are influenced by salinity. As mentioned under Section A7, Object 2 (Model Selection), the viability of this manipulation in QUAL2K will need to be thoroughly investigated and found to have no unintentional consequences or else WASP will likely be the model of choice.

Statistical (quantitative) and visual (qualitative) methods will be employed to evaluate the acceptability of the selected model's calibration and verification. Model calibration and verification are defined as follows:

- Calibration—the first stage of testing and tuning a model to a set of observational data, such that the tuning results in a consistent and rational set of theoretically defensible input parameters.
- Verification—Subsequent testing of a calibrated model to additional observational data to further examine model validity and preferably under different external conditions than those used during calibration. (from Thomann and Mueller, 1987)

Calibration is a systematic procedure of selecting model input parameters that result in model predictions that best match the observational data. In addition, the adjustments of input parameters should be within literature-suggested ranges from such sources as TNRCC (1995) and Bowie et al. (1985). For any input parameters without direct measurement within the project area and literature values, expert judgment will be utilized.

Within the separate verification step, the input parameters defining such things as kinetic rates will remain at the values used in the calibration step and separate sets of observational data are used for comparison purposes. The combined steps of model calibration and verification are referred to as a model validation process within this QAPP.

In the event that the verification process indicates that the predictions of the model(s) are unacceptable based on the general goals and targets in Table A7.1 and qualitative measures from visual inspection of graphical data comparisons, the model(s) will be recalibrated to the

original verification data sets and then verified against the original calibration data sets. While the recalibration process is not the preferred method of validating a model, this process recognizes the inherent difficulties of simulating DO. In this case traditional point source contributions are of secondary importance to other sources and processes that are much more difficult to quantify.

TIAER will use two main types of approaches to maintain quality assurance for model validation: graphical comparisons and statistical calculations.

(1) Graphical Comparisons:

- a. Longitudinal plots (along the Pecos River) of model predictions along with flow and water quality observed data will be visually reviewed, using common sense and professional expertise to judge if they are within reasonable ranges.
- b. Model predicted data will be compared to determine if they are in reasonably logical relationships to their environments or geological locations, e.g., downstream flow equals the summation of upstream flows.

(2) Statistical calculations, comparing simulated and observed data with Microsoft Excel Statistics or the UNIVARIATE procedure in SAS, and/or other statistical methods in SAS.

- a. Descriptive statistics, such as means, standard deviations, mean errors, and relative mean errors.
- b. Parametric pair-t test or non-parametric sign test (depending upon the normality of a distribution).

The validation process for the DO model will be documented in the technical report developed for this task. Within the document appropriate graphics and text will discuss and explain the validation process used and the results and conclusion of the validation of each model.

In conclusion, through use of graphical and statistical methods to evaluate the degree to which a model corresponds to reality, the validation process determines the usefulness of a model for the objective of estimating the load allocations and percent pollutant reductions needed to achieve desired DO loadings in the Pecos River. The goal of the validation process, as used herein, is to demonstrate that to the degree a model can represent a real-world system, the same model is considered useful for that same real-world system to determine the pollutant reductions required to achieve desired water quality goals.

Once the DO model of the Pecos River system is validated, a sensitivity analysis of key input parameters will be performed to determine response of the predictions of the model. This analysis will provide an indication of the importance of knowledge uncertainty on kinetic rates and other input parameters on predicted DO concentrations. More elaboration on the sensitivity analysis is provided in Section A7 Quality Objectives & Criteria; Objective 4: Perform Sensitivity Testing.

Section B8: Inspection/Acceptance Requirements for Supplies and Consumables

Not relevant.

Section B9: Data Acquisition Requirements (Non-direct Measurements)

The datasets listed in the Table B9.1 will be used to create the databases, input data, and validation data sets for the analytical tools to be constructed and applied on the DO TMDL. No additional validation of these datasets will be performed because they are either from state- and national-level recognized and accepted sources or have already been validated before their inclusion into the respective databases of origin database. The table provides the data type, the data source, and the intended use and relevance to construction of the project's analytical tools and their application.

Table B9-1. Non-Direct (Acquired) Data Required for Development and Application of Analytical Tools

Data Type	Data Source	Use/Relevance
Routine ambient water quality data in SWQMIS	TCEQ, collected by IBWC, TCEQ. [Moderate data volume.]	Validation of DO model
Continuous water quality monitoring (CWQM) data	TCEQ, collected by TCEQ; available from TCEQ website. [Large data volume]	Validation of DO model
Digital elevation models (DEM)	USEPA-BASINS website preferred; webGIS and GeoCommunity websites as alternatives. [Large data volume.]	Segmentation delineation and elevation data for DO model
Weather data	USEPA-BASINS website; NCDC and NWS websites on NOAA. [Large data volume.]	Input data to DO model
Stream cross-section data	TCEQ, collected by TCEQ; TPWD, collected by TPWD; available from website, reports, and special study PMs. [Small data volume]	Input data to DO model
Streamflow data	USGS web site. [Large data volume.]	Validation of DO model
Municipal & Industrial WWTP data	TCEQ Information Resources Division data and USEPA ECHO website (USEPA ICIS-NPDES). [Small data volume. Self-reporting data provided by permit holders.]	DO model input; provides historical discharge quantity and quality data for point sources
Water rights information and data	TCEQ Water Rights Team databases; some available on-line. [Small data volume anticipated.]	Input data to DO model
Saltcedar treatment areas	TWRI and other project partners. [Moderate data volume]	Input data to DO model
Miscellaneous geographic data (roads, streams, boundaries, etc.)	TNRIS; North Carolina State Univ. Libraries geospatial data services website; U.S. Census Bureau website; Montana State University Geographic Locater website. [Large data volume.]	Input data to DO model

It is anticipated that for some continuous time data needed for the project, gaps could exist in the data. Typically, for streamflow data the USGS will use appropriate estimation procedures to fill-in data gaps and note the data accordingly. However, the possibility also exists for data gaps with weather data and these data typically are not filled in. The following procedure will be used to estimate data to fill-in data gaps. For gaps in the data of four hours or less, estimates will be made using linear interpolation. Gaps longer than four hours will be filled-in by comparing all continuous segments of the same data set and selecting the one which most closely matches the values and slopes at the beginning and ending points of the gap so that a subset of actual continuous data can be spliced in most seamlessly.

Because the data needs for the model required for this project can be extensive, it is likely that various data limitations will occur regarding information needed for developing the models, for model input, and for model validation. Data limitations will be addressed in a hierarchical manner. The necessary data will first be sought from sources within the Pecos River watershed. If multi-sources of needed data are available, for example geographic information system land use and land cover data for different time periods, then typically the preference will be to use the data most representative of the conditions to be simulated by the model. If watershed specific data are not available or are insufficient, similar data from adjacent watersheds may be appropriate in some instances. An example of appropriate data from adjacent watersheds would be weather data from stations nearby but outside of the watershed. For the DO modeling, many of the water quality kinetic rates will not be determined or available from either watershed-specific data or nearby watersheds, so, as is typical, these rates will be based on literature values and professional experience.

Section B10: Data Management

All data files used as model input for this project will be stored in a secured, password-protected directory. Only authorized project participants, i.e., the TIAER PM and TIAER Data Manager (DM), be able to store and manipulate the files in the project directory. The types of project data files are described in the Migration/Transfer/Conversion section.

Information about the data files and types of data contained in each will be clearly documented to provide identification and traceability for all modeling inputs. The TIAER PM will be responsible for ensuring that all data files used for the project are included in the directory and that those files used as model input for the final modeling results are clearly distinguished from initial or intermediate versions of the dataset.

Data management procedures for all types and sources of data including raw data files from acquired (non-direct) data; model input data files; and model output files from calibration, verification, and allocation scenarios are described in this section.

Migration/Transfer/Conversion

The TIAER DM will transfer electronic data files to the project directory, which is located on the TIAER Intranet, from the Internet.

The various types of data to be downloaded from the Internet are included in Table B9.1. Databases on the Internet are stored in a variety of formats. Some data or files required for the project can be downloaded from the Internet into text or Excel files, where they can be manipulated to create text files or other types of data files that can be used directly by models. For Internet-downloaded data or files too large to be directly used by models, TIAER staff will write programs in Visual Basic, VBA, or FORTRAN to transform the data into the format required by models.

Ensuring Data Quality

The simplest and most straightforward means of maintaining high-quality data is to thoroughly train all individuals involved in data collection and data management procedures in appropriate data qualification protocols and data management procedures. If all project data users are familiar with protocol and use identical procedures, potential problems will be averted.

Internet data will be downloaded from authorized organizations or websites when they are needed for modeling activities. It is not uncommon that some Internet-downloaded data, e.g., weather data, do contain gaps. Missing or empty data values (i.e., gaps) can occur, and these data gaps will be filled in as discussed in Section B9 Non-Direct Measurements.

Geographic Information System (GIS) DEM data will be checked for integrity in such areas as projection, sinks, tears and holes.

Internet-downloaded data will be carefully verified and documented if potential errors are discovered during modeling activities. For example, if precipitation data downloaded from an authorized organization indicates a possible shifting of day of recorded rainfall due to the time that observations are recorded, the data will be compared to other sources, e.g., local weather data centers to assure data quality. Any necessary corrections will be made to the data and noted in the project data log.

Files downloaded from the Internet will be checked for file transfer errors by randomly sampling transferred data and comparing them to the original data. This data sampling will involve the data at the beginning, middle and end of the data files. In the similar way, the copied/pasted data, equations, and data manipulations used in preparing model input data will be randomly checked at least once.

Electronic Codebook and Data Logs

As part of the QA procedures for this project, the TIAER PM will maintain an electronic codebook listing data management decisions, procedures, and operations, which ensures consistency and traceability for the data across time and changing staff.

As an essential part of the database codebook, the TIAER PM will create a log that describes each step in data management procedures and includes Internet-downloaded data entry and QA checks of Internet-downloaded data.

All downloaded data files will have a separate entry in the project data log. Metadata on each input dataset is recorded in an electronic project file. The metadata include website or Intranet address, date of download, TIAER staff responsible for download, directory and file name where downloaded data is stored, list of the variables (data fields) needed for modeling activities and their description when necessary, and how the data will be used for the project.

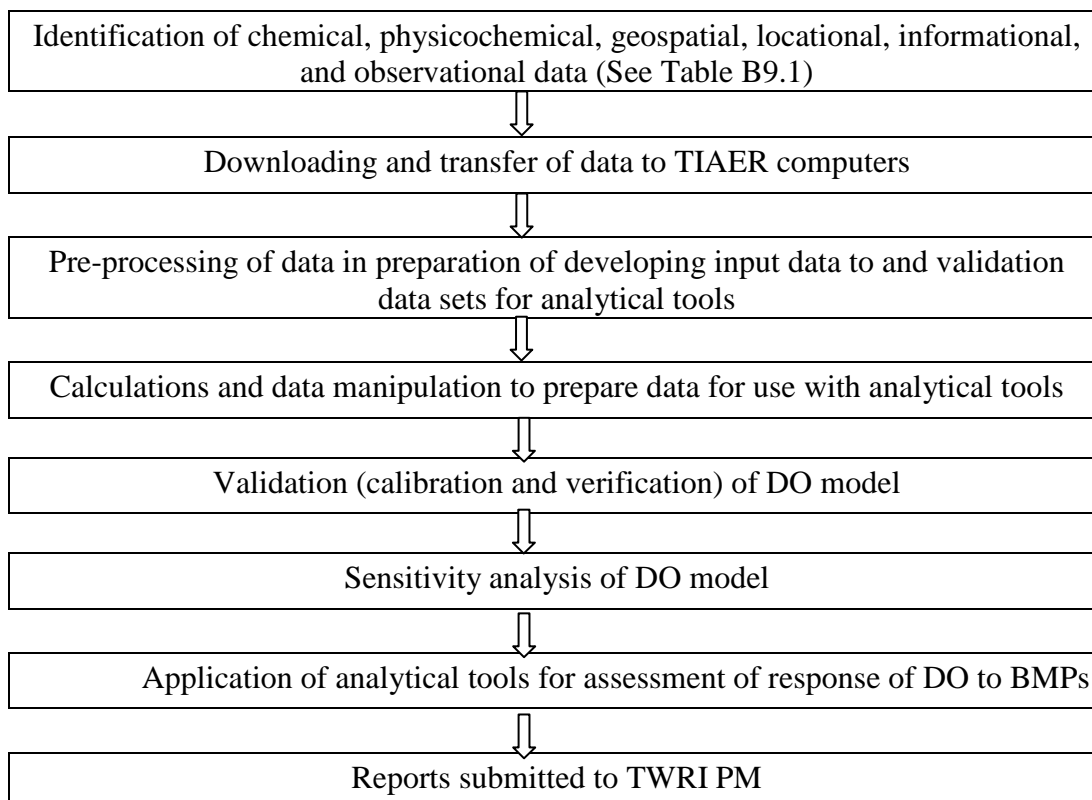
Data Verification/Validation

The control mechanisms for detecting and correcting errors and for preventing loss of data during data reduction, data reporting, and data entry are contained in Sections D1, D2, and D3.

DATA MANAGEMENT PROCESS

A flow chart is provided below that traces the path of the data from acquisition to final use and storage.

Process Chart of Data Flow



Record Keeping and Data Storage

TIAER's general record-keeping and document control procedures are contained in the TIAER Quality Assurance Manual and this QAPP. For the modeling portion of this project, electronic files for the following will be kept for at least five years:

- Original data sets from the sources listed in Table B9.1,
- Metadata for main input datasets, including website address from which data are obtained, date of data download, initials of staff member responsible for download, general description and use of data, original provider of data, name and location of file in which the data are stored, name and location of file in which the data are manipulated (if appropriate),
- Spreadsheets and data files documenting calculations and data manipulations used in preparing data for use with analytical tools,
- Plots, graphs, curves, and other representations used in decision-making aspects of the project,

- Documentation of all changes to the models used in production of the final modeling results,
- Documentation, where necessary, of accommodations taken to remediate lack of desired types of data for application of the model,
- Copy of each model code and its executable version as used to produce results for the project, including any changes to the original model used in production of the reported results,
- Final input data set files and modeling result files used in calibration and verification,
- Final results of all sensitivity analyses
- Files documenting the various types of graphical and statistical comparisons required for model validation (listed in Table A7.1) and results of the final comparisons, and
- Copies of all original results from applications of the model(s) that are used in project reports, with details of scenarios clearly described.

Data Handling

Data are transferred to TIAER computers for use with Microsoft applications, applications of analytical tools, and SAS programs. Data integrity is maintained by the implementation of password protection which controls access to directories in which project data are stored.

Backup/Disaster Recovery

As an electronic data protection strategy, TIAER utilizes Double Take software to mirror the Primary Aberdeen 1.2TB file server (raid 5 fault tolerant) that will be mirrored to a secondary Aberdeen Abernas211 file server (raid 5 fault tolerant). This provides instant fault recovery rollover capability in the event of hardware failure. TIAER also exercises complete backup of its Primary server to LTO-3 Quantum ValueLoader on a weekly basis, coupled with daily incremental backups. This provides a third level of fault tolerance in the event that both the primary and secondary server are disabled. TIAER will maintain all cyclic backup tapes for 26 weeks prior to reuse saving the 1st tape in the series indefinitely to preserve a historical snapshot. This will facilitate recovery of data lost due to human error. Backup tapes are stored in a secure area on the Tarleton University campus and are checked periodically to ensure viability. If necessary, disaster recovery can also be accomplished by manually re-entering the data.

Archives/Data Retention

Original data recorded on paper files and as electronic data are stored for at least five years. Data in electronic format are stored on tape drives. Complete electronic data sets are archived on tape backup and retained on the Tarleton State University campus in a fire-resistant storage area managed by the Tarleton ITS department.

Information Dissemination

Project updates will be provided to the TWRI PM and TSSWCB PM in progress reports and the information will be made available at stakeholder meetings. Input data and model outputs resulting from the project described in this QAPP will be accessible to the general public.

HARDWARE/SOFTWARE CONFIGURATION

The types of computer equipment, hardware, and software to be used on the project are provided in Table B10.1.

Table B10-1. Listing of Project Hardware and Software

Equipment & software name	Type	Number	Specification	Use
Dell PC desktop Computers	Hardware	2	P4, CPU 3.2 GHz, 2 GB Ram, Windows XP professional 2002	Support modeling activities
AberNAS 1.5 TB Server	Hardware	1	P4 CPU 3.0GHz,1GB RAM Windows 2003 Server SP2	Primary Server, Veritas Backup Software, Double-Take Real-Time Replication Software
AberNAS 1.2 TB Server	Hardware	1	P4 CPU 3.0GHz,1GB RAM Windows 2003 Server SP2	Secondary Server, Veritas Backup Software, Double-Take Real-Time Replication Software
Quantum Autoloader	Hardware	1	LTO-3 Ultrium Backup Tape Unit	400GB/800GB Compressed Backup
ArcView 3.3	Software	1	Window interface	Create input data for DO model
ArcGIS 9.3 or higher	Software	1	Window interface	Create input data for DO model
SAS 8.2 or higher	software	1	Window interface and DOS interface	Analyze output data from models, and measurement data
Visual Fortran 6.0 or higher	software	1	User interface: Windows	Calibration and development of models
QUAL2K 2.11 or higher	software	1	Window Excel interface and DOS interface	Hydrology and water quality modeling

Equipment & software name	Type	Number	Specification	Use
WASP 7.4 or higher	software	1	Windows interface	Hydrology and water quality modeling
Microsoft Office Software (Excel, Word, PowerPoint)	software	2	Windows platform	Data preparation, report writing, presentations

Section C1: Assessments and Response Actions

As described in Section A, generally, and in Section B9, specifically, the analytical tools will be developed from observational data from many sources. A wide range of data is required to set up a model that accurately simulates DO levels in the Pecos River. These data will be organized into various data files and databases to provide input data for validation of the DO model. No additional validation of these datasets will be performed because they are either from state- and national-level recognized and accepted sources or have already been validated before their inclusion into their respective databases of origin.

As oversight and assessment measures, all input data to the analytical tools will be independently assessed for accuracy and completeness by an appropriately trained TIAER staff member. In response to any discrepancies and errors detected, the independent staff member will document necessary changes and corrections, report these to the lead modeler, and the lead modeler will make the necessary corrections.

All data and equations in Excel data spreadsheets used for preparing input data that are newly created or calculated from other sources (e.g., data prepared for QUAL2K or WASP) will be examined at least twice, with one examination by an independent, appropriately trained TIAER staff member. Any errors and discrepancies uncovered during the examinations will be reported by the reviewer to the lead modeler, who will perform any necessary corrections to data and equations. Where appropriate, simple diagnostic approaches (e.g., trend plots) will be applied to identify any problematic areas.

The validation process for the DO model will involve the TIAER PM. The PM will maintain a logbook for use in documenting input data refinements during the validation process. During the calibration step, the PM will systematically adjust appropriate input parameters within the range of meaningful values based on observations made in the watershed, literature, and expert opinion and judgment for the purpose of achieving the optimal comparison of model output to the observational data. The graphical and statistical measures as discussed and presented in Sections A7—Quality Objectives & Criteria and B7—Model Calibration and Verification [Validation] will be the means of assessing progress in the validation process. After calibration is completed and prior to commencing the verification step, TIAER's PM will assess all adjusted input parameters to ensure that values stayed within acceptable ranges.

During the verification step, model predictions will be evaluated against observation data using the same graphical and statistical techniques as used during calibration. Based on this evaluation and the general targets and goals in Table A7.1, the TIAER PM will assess whether the model is acceptably validated. If validation is acceptable, the model will be ready for application; otherwise the model will need to undergo a recalibration process requiring further input parameter adjustment, calibration to the original verification data sets, and verification to the original calibration data sets.

Once the DO model of the Pecos River system is validated, a sensitivity analysis of key input parameters will be performed to determine response of the predictions of the model. This

analysis will provide an indication of the importance of knowledge uncertainty on kinetic rates and other input parameters on predicted DO concentrations. Using experience gained from the validation process, the TIAER PM will determine both the input parameters to be included in the sensitivity analysis and the variation of the parameter to be evaluated. Typically, re-aeration coefficients, ammonia and biochemical oxygen demand decay rates, sediment oxygen demand rates are primary input parameters considered in a sensitivity analysis. Rates governing benthic and suspended algae net growth are also important as diel fluctuations will be modeled as well. For this application to the Pecos River, streamflow and TDS (and its influence on DO saturation concentration) will also be considered in the sensitivity analysis. Input parameters will be varied +/- 50 percent, unless experience obtained during model validation indicates to the contrary, and evaluated on an individual basis for their influence on DO concentrations. Sensitivity analysis results will be presented in graphical mode in the task technical report.

Table C1.1 presents the types of assessments and response actions for activities applicable to the QAPP.

Table C1.1 Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party(ies)	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	TWRI, TIAER	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of performance and data quality.	Report to project lead in Quarterly Report
Technical Systems Audit	Minimum of one during the course of this project.	TSSWCB QAO	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP. Facility review and data management as they relate to the project.	30 days to respond in writing to the TSSWCB QAO to address corrective actions

Corrective Action

Results will be reported to the project TWRI QAO in the format provided in Section A9. If agreement is not achieved between the calibration standards and the predictive values, corrective action will be taken by the TIAER PM to assure that the correct files are read appropriately and the test is repeated to document compliance. Corrective action is required to ensure that conditions adverse to quality data are identified promptly and corrected as soon as possible. Corrective actions include identification of root causes of problems and successful correction of identified problem. CARs (Appendix A) will be filled out to document the problems and the remedial action taken. CARs will be transmitted to the TWRI QAO for inclusion in the project QPR and for proper archiving. The TWRI QAO will also assist TIAER in resolving the issue at hand if TIAER cannot be resolved on its own. In the event that a feasible solution cannot be reached or standards cannot be achieved, the TWRI QAO will work with TSSWCB to arrive at an agreeable compromise.

Section C2: Reports to Management

Quarterly progress reports developed by the TWRI PM, with assistance from TIAER project personnel will note activities conducted in connection with the water quality modeling project and will include items or areas identified as potential problems, and any variations or supplements to the QAPP. CARs will be utilized when necessary (Appendix A). CARs will be maintained in an accessible location for reference at TWRI and disseminated to individuals listed in section A3. CARs that result in any changes or variations from the QAPP will be made known to pertinent project personnel and documented in an update or amendment to the QAPP.

If the procedures and guidelines established in this QAPP are not successful, corrective action is required to ensure that conditions adverse to quality data are identified promptly and corrected as soon as possible. Corrective actions include identification of root causes of problems and successful correction of identified problem. CARs will be filled out to document the problems and the remedial action taken. Any problems encountered and solutions made will be included in project QPRs and disseminated to individuals listed in section A3.

Section D1: Data Review, Validation and Verification

All input data derived from data acquisition and used in development of the project's analytical tools will be checked for accuracy by staff with appropriate training. For these large data sets, data checks will consist of verification of a statistical sampling (e.g., 10 percent of relevant data) of the input data. Any errors in input data will be corrected at that time. No additional validation criteria are necessary for acquired data obtained for the project because they are either from state- and national-level recognized and accepted sources and have already been validated before their inclusion into their respective databases of origin.

All data obtained will be reviewed, validated, and verified against the data quality objects outlined in Section A7, "Quality Objectives and Criteria for Model Inputs / Outputs." Only those data that support the intended uses and objectives will be considered acceptable for use.

Departures from validation targets and goals for analytical tools in Sections A7—Quality Objectives & Criteria will be evaluated carefully by both the lead modeler and TIAER PM. No state or national numeric criteria are recognized and accepted for the validation process of mechanistic models, in general, and DO models, in particular. Because of the absence of such criteria, it is recognized that the numerical targets and goals specified in Table A7.1 are for guidance purposes and not absolute requirements. Nonetheless, departures, such as relaxations of the target values of statistical measures will be appropriately documented as the validation process proceeds. Justification for any departures will be documented by the TIAER PM.

Section D2: Validation Methods

TIAER staff and management are responsible for the integrity and verification of the data and of the computations each task generates or uses throughout each process.

Verification and integrity review of output data and associated calculations from each task will be performed using self-assessments and peer review, as appropriate to the project task, followed by technical review by the manager of the task. The verification output (listed by task in Table D2.1) and associated calculations will be evaluated against project objectives (Section A7) and will be checked for errors, especially errors in transcription, calculations, and data input. Potential outliers in input data are identified by examination for unreasonable data, or identified using computer-based statistical software. If a question arises or an error or potential outlier is identified, or any other issue arises, the manager of the task responsible for generating the data is contacted to resolve the issue. Issues which can be corrected will be corrected and documented electronically or by initialing and dating the associated paperwork. If an issue cannot be corrected, the task manager will consult with higher level project management to establish the appropriate course of action, or the data associated with the issue will be rejected. The TIAER PM, with the concurrence of the TIAER QAO, verifies that the data meet the data quality objectives of the project and are suitable for reporting to TSSWCB.

Specific validation methods necessary for this project have been established in other sections of this QAPP. In summary:

- Validation and review of input data sets to the model through random statistical sampling of the input data against original data sources.
- DO model verification output (listed by task in Table D2.1) and validation process will be performed as described in Section A7 wherein graphical and statistical measures will be used to evaluate prediction (or output from model state variables) against observational data separated into separate calibration and verification data sets.
- The target goals in Table A7.1 will be used to guide the validation process, but due to the absence of accepted numeric criteria to measure model performance, this process will contain qualitative and subjective components.

Table D2-1. Model Validation Procedures

Tasks	Responsible Entity/Individual
Raw Data Review	
Raw data processing	TIAER DM
Input data set creation	TIAER DM & TIAER PM
Input data set review	TIAER PM
Validation Run	
Output data review	TIAER PM
Performed fit calculations	TIAER PM
Review fit calculations	TIAER PM
Compare fit calculation results to criteria	TIAER PM
Adjust input data, verify validation, or explain why criteria is not met	TIAER PM
Data Set Review	
The test report has all required information as described in Section A9 of the QAPP	TIAER PM
Confirmation that input data and model outputs have been reviewed	TIAER PM
Gaps in raw data have been reconciled and documented	TIAER PM
Data meets conditions of end use and are reportable	TIAER PM
Adherence to QA/QC Requirements	
Perform check of adequacy of necessary documentation	TIAER QAO

Section D3: Reconciliation with User Requirements

DO modeling activities consist of acquisition of data, the construction of model input, model validation, sensitivity analysis and subsequent application of the model to determine feasible management scenarios and are designed to provide results that meet user requirements. The purpose of the validation process is to establish the usefulness of the model for evaluating the stressors and causes of the DO impairment in the Pecos River. The purpose of the model applications is to evaluate individual BMPs and suites of BMPs for the purpose of predicting improvement in DO from these activities.

The construction and application of the DO model will be reported in a technical report. The technical report will describe assumptions and calculations used in representing the BMPs in the model so that reviewers and interested parties can understand the model application process, limitations of the data, and estimations used in developing the model. Any limitations on use of the DO model will be included in the technical report and reflected in the findings.

References

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Appendix A: Corrective Action Report

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Corrective Action Report

SOP-QA-001

CAR #: _____

Date: _____

Area/Location: _____

Reported by: _____

Activity: _____

State the nature of the problem, nonconformance or out-of-control situation:

Possible causes:

Recommended Corrective Actions:

CAR routed to: _____

Received by: _____

Corrective Actions taken:

Has problem been corrected?:

YES

NO

Immediate Supervisor: _____

Program Manager: _____

TWRI Quality Assurance Officer: _____

TSSWCB Quality Assurance Officer: _____